§ 3. Installation of a 168GHz Gyrotron System for High Power ECH

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For the 6th experimental campaign in which higher power injection of millimeter waves were required to obtain high performance plasmas with high electron temperature and density. The flexibility of the injection method was also needed. For that purpose one more 168GHz gyrotron were installed. This gyrotron was operated by a solid state type power supply and connected to the transmission line which had been used for the 84GHz gyrotron system. The addition of the 168GHz system allowed to realize over 2MW power injection in total, i.e. two 82.7GHz, two 84GHz and four 168GHz gyrotron systems.

On the installation there were two main subjects; one was a protection method of the gyrotron for some faults such as arcings on the output window or in the transmission line. Another was the output power coupling of the gyrotron with the corrugated waveguide.

For the former the optical arc detectors were mounted on the miterbend back plates and the Matching Optics Unit (MOU). The fault signals were guided to the body high voltage power supply and turned off high voltage within several tens micro seconds.

For the latter two MOUs were prepared to couple the gyrotron output effectively with the corrugated waveguide, one was for the beam shaping and another was for the beam alignment. The first MOU is specially designed phase correcting mirrors. The second MOU consists of some flat and focusing mirrors, polarizer mirrors, switches and equipped with a brick dummy load for long pulse conditioning. A similar MOU is adopted in the 82.7GHz gyrotron system and successful results are obtained. The polarizer mirrors with larger surface area reduce the power density of incident waves, resulting in the less arcings on them. Figure 1 shows the configuration of the system. The output beam with flatter power profile is modified to the gaussian beam by two phases correcting mirrors, M1 and M2. After flat mirrors, M3 and M4 the beam is injected on the polarizer mirrors, P5 and P7. The mirror, M6 is the approximately parabolic mirror to focus the expanding beam to the waveguide entrance. The switching mirror, SW, can be set to change the ray path and introduce the beam into the bricks.

The alignments of the waveguide axis were also performed by means of a He-Ne laser on this line. After that work we measured the transmitted power at several positions and estimated the transmission efficiency. At first a water dummy load was set behind the first MOU and operational range of the gyrotron was investigated as a function of the accelerating voltages and magnetic field in the cavity. A portable water dummy load was installed in the transmission line near LHD and the transmitted power was measured. On the basis of these measurements the transmission efficiency was be evaluated and the injection power into the LHD vacuum vessel was estimated.

This 168GHz system was operated steadily throughout the experimental campaign without any arcings in the MOU and transmission line. Because this gyrotron has an extremely narrow operational regime with respect to the accelerating voltage, it is difficult to obtain increasing injection power.

The continuous effort for the optimization of the operational regime and improvement of the transmission efficiency will be needed hereafter.

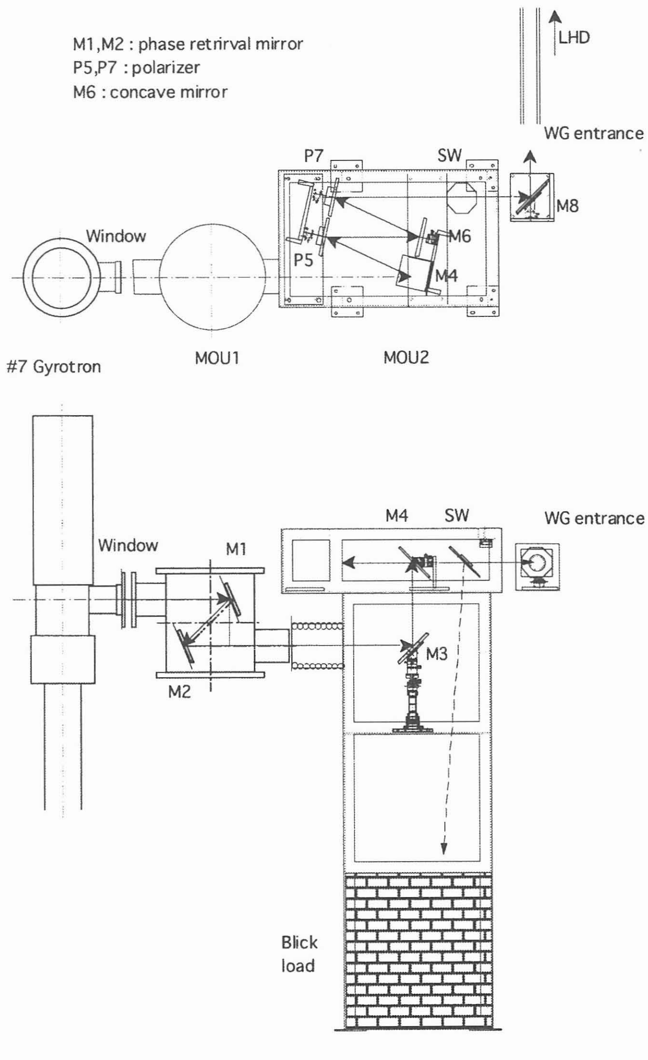

Fig. 1. Schematic of configuration of 168GHz system.